UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Faculty of Electronic and Computer Engineering

ENHANCED DESIGN OF ELECTRONICALLY RECONFIGURABLE INTEGRATED MICROWAVE FILTER AND ANTENNA FOR WIRELESS COMMUNICATION SYSTEMS

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SAM WENG YIK

A thesis submitted
in fulfillment of the requirements for the degree of Doctor of Philosophy

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DECLARATION

I declare that this thesis entitled "Enhanced Design of Electronically Reconfigurable Integrated Microwave Filter and Antenna for Wireless Communication Systems" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature	:	....
Name	:	....
Date	:	....

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Doctor of Philosophy.

Signature : ....

Supervisor Name : ....

Date : ....

DEDICATION

To my beloved mother and father

ABSTRACT

The reconfigurable integrated filter and antenna is one of the major interest for researchers due to the potential significant advantages compare to the typical standard integrated structure. The growth in reconfigurable integrating technology is not limited to a single tunable parameter such as operating frequency, bandwidth and attenuation but it can be combination parameters depending on the applications. There are many techniques have been developed to achieve adaptable reconfigurable integrated filter and antenna but majorities of the reconfigurable designs are focused on a single element either on an antenna or the filter. Thus, it limits the tunable range and flexibility response of the reconfigurable design will be a challenging task. On the other hand, developing a Ultra-Wideband (UWB) antenna is one of the crucial components for UWB communications systems and has been widely studied for many years. Moreover, the reconfigurable UWB designs can be developed the desired filtering antenna which can reject unwanted signal interferences. However, most of these techniques produce excessive band rejection, which leads to reject desired frequencies, thus producing a narrowband notch characteristics is a challenging issue. Therefore, the aim of this research is to design novel structure of reconfigurable integrated technique of planar structure which promises a new potential functionality of the microwave devices. Two designs approach were introduced which is reconfigurable SIW filter and antenna and reconfigurable dual band-notched UWB antenna using FR-4 substrate and Roger Duroid RO4350B with dielectric constant of 4.6 and 3.48 respectively. To realize the concept, reconfigurable SIW filter and reconfigurable patch antenna have been combined using the multilayer technique into a single structure while UWB antenna and reconfigurable notch filter were combined on the same planar. To validate the design technique, the equivalent circuit model of the tunable varactor diode network is presented to study the tunability mechanism. Two commercial software programs that have been used in the design and development of two main designs namely Advanced Design System (ADS) software and CST Studio Suite software. All designs were simulated, manufactured and measured. Reconfigurable integrated SIW filter and antenna provide a good attenuation tuning range about 15.5 dB with improvement up to 55 % and only shifts 1 MHz from the origin centre frequency while reconfigurable UWB antenna with band-notched provide a good range up to 210 MHz. This design has smaller compact size of 37.6 mm x 28.0 mm with bandwidth for peak notch of 224.76 MHz and 89.90 MHz for both notches. The experimental results show a good agreement with the simulated results. The benefits of the reconfigurable integrated design are potentially miniaturizing overall structure, good tuning capability, easy to fabricate and cost effective. The outcomes of the proposed reconfigurable integrated design may facilitate improvements in an integrated technique with a good tuning capability for wireless communication systems.

ABSTRAK

Konfigurasi semula integrasi penapis dan antena adalah salah satu kepentingan utama penyelidik kerana kelebihan yang signifikan berbanding struktur integarsi biasa. Pertumbuhan konfigurasi semula integrasi teknologi tidak terhad kepada parameter tunggal seperti frekuensi operasi, lebar jalur dan pelemahan tetapi ia boleh dijadikan parameter gabungan bergantung kepada aplikasinya. Banyak teknik telah dilakukan mengenai konfigurasi semula integrasi penapis dan antena, tetapi majoriti reka bentuk tertumpu pada satu elemen sama ada pada antena atau penapis. Malahan, ia mengehadkan julat boleh tala dan fleksibiliti penapis dan antena tersebut serta menjadi tugasan yang mencabar. Sebaliknya, antena UWB adalah salah satu komponen yang penting dalam sistem komunikasi UWB dan telah dikaji selama bertahun-tahun. Lebih-lebih lagi, konfigurasi semula antena UWB dengan jalur takuk boleh dibangunkan untuk membentuk satu antena penapisan di mana boleh menapis gangguan isyarat yang tidak diingini. Tambahan pula, kebanyakan teknik ini menghasilkan tolak jalur yang berlebihan dan menapis frekuensi yang diingini, oleh itu untuk menghasilkan jalur sempit merupakan isu yang mencabar. Oleh itu, tujuan penyelidikan ini adalah untuk mereka bentuk dan membangunkan satah struktur konfigurasi semula integrasi penapis dan antena baru yang berfungsi dalam peranti mikro gelombang. Dua pendekatan reka bentuk diperkenalkan iaitu konfigurasi semula integrasi penapis pandu gelombang berinterasi substrat (SIW) dan antena tampalan dan konfigurasi semula antena UWB dengan jalur takuk dengan menggunakan substrat FR-4 dan Roger Duroid RO4350B dengan pemalar dielektrik 4.6 dan 3.48. Untuk merealisasikan konsep ini, konfigurasi semula penapis SIW dan konfigurasi semula antena tampalan boleh digabungkan menggunakan teknik berbilang lapis ke dalam struktur tunggal manakala antena UWB dan konfigurasi semula jalur takuk digabungkan dalam satah yang sama. Untuk mengesahkan teknik reka bentuk, model litar setaraf rangkaian diod varactor boleh dikaji melalui mekanisme julat boleh tala. Dua perisian komersil yang digunakan dalam reka bentuk dan pembangunan iaitu Advanced Design System (ADS) dan CST Studio Suite. Konfigurasi semula integrasi penapis SIW dan antena menyediakan penalaan pelemahan yang baik iaitu 15.5 dB dengan penambahbaikan sebanyak 55 % dan hanya beralih sebanyak 1 MHz dari frekuensi asal manakala pentatahrajahan semula antena UWB dengan jalur takuk memberikan penalaan frekuensi yang baik sehingga 210 MHz. Reka bentuk ini mempunyai saiz yang kecil iaitu 37.6 mm x 28.0 mm dengan jalur lebar untuk notch puncak iaitu 224.76 MHz dan 89.90 MHz untuk kedua-dua notch. Semua reka bentuk disimulasikan, dihasilkan dan diukur. Keputusan eksperimen menunjukkan persetujuan yang baik dengan hasil simulasi. Manfaat konfigurasi semula integrasi reka bentuk berpotensi untuk membentuk struktur yang kecil, keupayaan penalaan yang baik, mudah dan kos efektif. Hasil daripada reka bentuk konfigurasi semula integrasi yang dicadangkan boleh menaik taraf peningkatan dalam teknik integrasi dengan keupayaan julat boleh tala yang baik untuk sistem komunikasi tanpa wayar.

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